8. APPENDIX B: FILTERS

This appendix describes the median filter that was used to precondition the digitized video images and the Sobel filter that was used to extract edges from the preconditioned images.

Median Filter

A median filter will remove noise spikes from the image without significantly blurring the edges. Very fine detail, such as sharp corners, will be removed by the median filter. For this report, a 3 x 3 median filter was used. Figure B-1 shows 9 image pixel values (X_1, X_2, ..., X_9) within the 3 x 3 filter window. In Figure B-1, the 3 x 3 filter window is centered on the image pixel value X_5.

X_1	X_2	X_3
X_4	X_5	X_6
X_7	X_8	X_9

Figure B-1. Filter window centered on image pixel value X_5.

The median filter outputs the image pixel value that is the median of the 9 image pixel values (X_1, X_2, ..., X_9). That is, the 9 pixel values are first sorted from low to high, and then the middle value is selected as the median. The median filtered image is obtained by sliding the 3 x 3 window over the entire input image. At each pixel for which the mask is centered in the input image, the median value is placed in the output image. Note that as an edge is crossed, one side or the other dominates the window and the output switches sharply.

Sobel Filter

The Sobel filter is an edge extraction filter that is implemented using two filters. One filter is designed to extract horizontal edges from the image and the other filter is designed to extract vertical edges. The outputs from the two filtering operations are then combined to give a composite edge extracted image. Figure B-2 gives the filter

mask that extracts the horizontal edges. Figure B-3 gives the filter mask that extracts the vertical edges.

-1	-2	-1
0	0	0
1	2	1

Figure B-2. Horizontal edge extraction filter mask.

-1	0	1
-2	0	2
-1	0	1

Figure B-3. Vertical edge extraction filter mask.

If both of the masks shown in Figures B-2 and B-3 are centered on pixel value X_5, as in Figure B-1, then the output response at pixel location X_5 from the horizontal edge extraction filter is

$$G_h = -1*X_1 - 2*X_2 - 1*X_3 + 1*X_7 + 2*X_8 + 1*X_9$$

and the output response at pixel location X_5 from the vertical edge extraction filter is

$$G_v = -1*X_1 + 1*X_3 - 2*X_4 + 2*X_6 - 1*X_7 + 1*X_9$$

Note that horizontal edges result in an output response G_h and vertical edges result in an output response G_v. Diagonal edges result in output responses G_h and G_v. The composite output response at pixel location X_5 from both filters is computed as

$$G = [G_h^2 + G_v^2]^{1/2}$$

The output image pixel values are obtained by computing the filter response G at each corresponding pixel in the input image, where both filter masks (Figure B-2 and B-3) are centered on the input image pixel.